SIEMENS

MOBILETT Plus HP

SP

Functional Description

From Serial No. 30800

English

Print No.: SPR8-220.041.02.02.02
Doc. Gen. Date: 09.03
Replaces: SPR8-220.041.02.01.02

Chapter	Page	Revision
all	all	02

Document revision level

The document corresponds to the version/revision level effective at the time of system delivery. Revisions to hardcopy documentation are not automatically distributed.

Please contact your local Siemens office to order current revision levels.

Disclaimer

The installation and service of equipment described herein is to be performed by qualified personnel who are employed by Siemens or one of its affiliates or who are otherwise authorized by Siemens or one of its affiliates to provide such services.

Assemblers and other persons who are not employed by or otherwise directly affiliated with or authorized by Siemens or one of its affiliates are directed to contact one of the local offices of Siemens or one of its affiliates before attempting installation or service procedures.

Contents

Training of customer support engineers

Due to the technology, used in this equipment, the setup, service and maintenance is only allowed to be performed by a customer support engineer with a Work Permit for MOBILETT Plus HP.

Text emphasis

⚠DANGER	**DANGER indicates when there is an immediate danger that leads to death or serious physical injury.**
⚠WARNING	**WARNING indicates a risk of danger that may lead to death or to serious physical injury.**
⚠CAUTION	**CAUTION used with the safety alert symbol indicates a risk of danger that leads to slight or moderate physical injury and/or damage to property.**
NOTICE	**NOTICE used without the safety alert symbol indicates a risk of danger that if disregarded leads or may lead to a potential situation which may result in an undesirable result or state other than death, physical injury or damage to property.**
NOTE	**NOTE contains information provided with special emphasis to facilitate proper use of the equipment or proper execution of a procedure, i.e. hints, tips.**

Required documents

- Instructions for use SPR8-220.201...
- Wiring diagram SPR8-220.051...

Safety information and protective measures

⚠CAUTION

- **When performing service work and tests adhere to:**
  - **the product-specific safety information in the documents,**
  - **as well as the general safety information contained in ARTD Part 2.**
- **Connect the MOBILETT Plus HP only to mains power supply outlet (receptacle), that corresponds to the installation requirements of VDE 0107 or country-specific regulations.**
- **Remove or install boards only when the generator is switched OFF. Adhere to the ESD guidelines .**
- **Checks and adjustments performed with radiation ON are identified by the radiation warning symbol . During these types of adjustments, radiation protective clothing must be worn.**

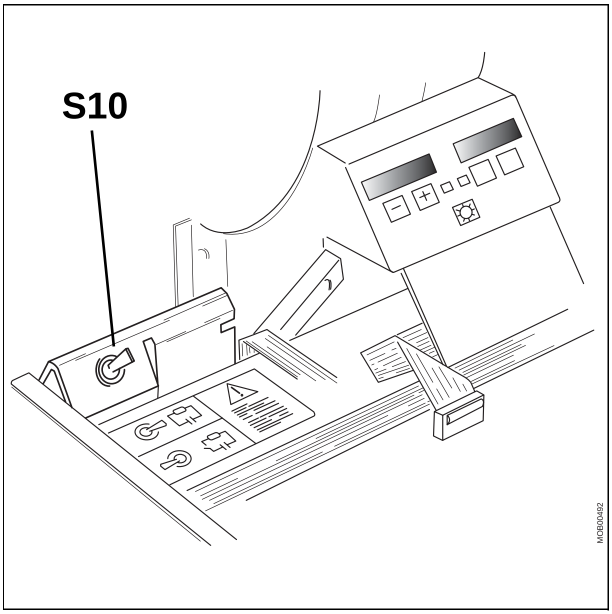


Fig. 1

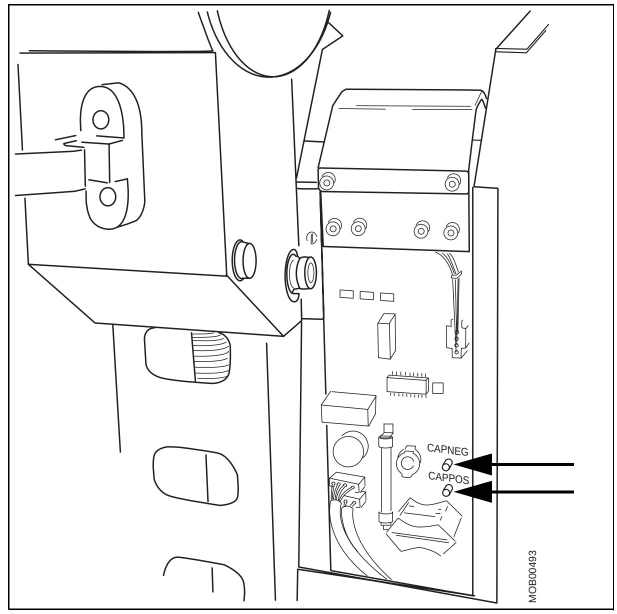


Fig. 2

Protective measures for batteries B10 and capacitors in power conversion unit M10 and M11

Comply with the information given in this section, before opening the system.

⚠DANGER

High Voltage!

Life-threatening electric shock hazard exists. Never work with the system open if the batteries are still connected and the capacitor is charged. If the batteries are connected, the complete system is powered on!

The capacitors in M10 and M11 may still be charged even if the system is switched OFF and the mains cable is disconnected. The capacitors in M10 and M11 must be considered charged until the protective measures listed in this section have been performed.

- System OFF (turn the main switch to **C**).
- Disconnect the mains cable.
- Remove the system upper cover.
- Discharge the capacitors in M10 and M11 with S10 (D7) (refer to Fig. 1).
- Wait 5 minutes; then remove the left and right covers, and the cover with the cassette compartment.

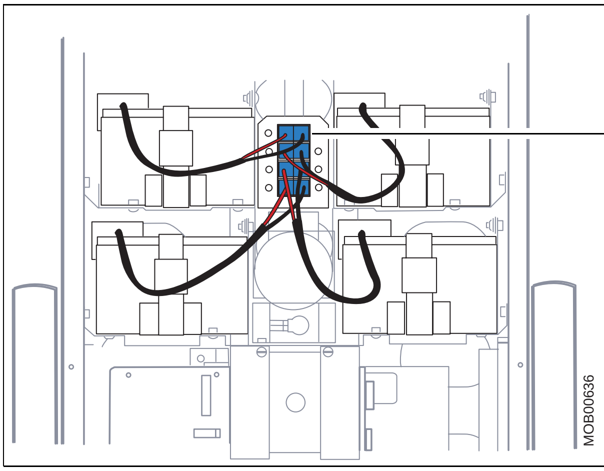


Fig. 3

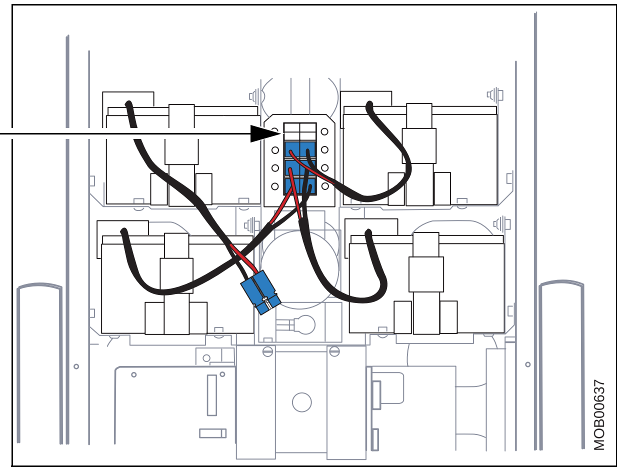


Fig. 4

- Disconnect batteries by removing one of the KBATT plugs (refer Fig. 3 and Fig. 4).
- Measure the residual voltage at test points CAPPOS and CAPNEG on board D7 (refer to Fig. 2). The voltage measured must be less than 2 VDC.

⚠WARNING

If the voltage measured between CAPPOS and CAPNEG is 0V, the measurement device could be defective or the wires between the CAPPOS and CAPNEG test points on the capacitor bank could be damaged.

The capacitors could still be charged.

In this case, proceed as follows:

- Make sure that the correct measurement range is set on the measurement device.
- Connect the measurement device to CAPPOS and CAPNEG.
- Switch S10 off. Connect the mains cable and switch the system ON.
- Check whether the voltage increases.
- Switch the system OFF, disconnect the cable and switch S10 on.
- Check whether the voltage decreases.

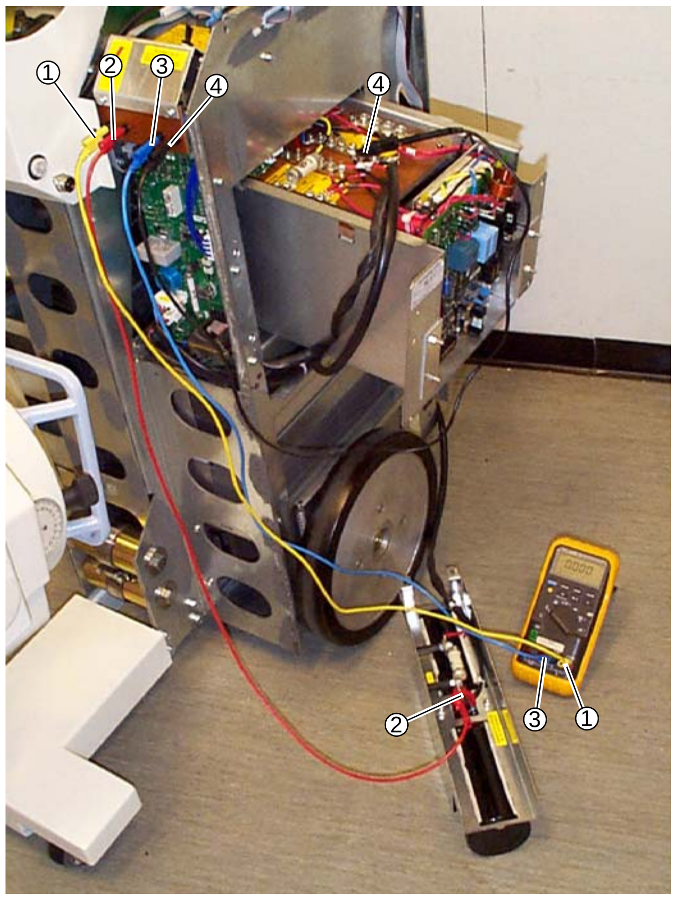
⚠WARNING

If U11 or U301 is blown the capacitor in M11 will not be discharged with S10.

The capacitors could still be charged.

Verify that U11 or U301 has not blown.The capacitor in M11 must then be discharged as stated below.

- Measure the voltage on the capacitors in M11 and check that the voltage level is <2 V DC. If not, discharge the capacitors with R103, see Fig. 5.



① Left connector on D7 to the + connector of the digital multimeter
② Second left connector on D7 to the fuse-side (U11) next to the capacitor
③ Second right connector on D7 to the - connector (GND) of the digital multimeter
④ Right connector on D7 to the P11 connector on the power conversion unit (M10)

Fig. 5

⚠WARNING

If the charging/discharging does not function, the power conversion unit M10 and M11 must be considered “charged”.

This means a risk of high voltage.

Use caution when performing measurements at the capacitors in M10 and M11.
Use only the specified measurement devices (350 V DC).

This page intentionally left blank.

The MOBILETT Plus HP is a battery powered mobile X-ray system with a microprocessor-controlled high frequency generator. Its application ranges from use in the intensive care, pediatric care, emergency room, radiology department and operation room.

Technical data

Power connection:

Single-phase line voltage, 100 - 130 V AC ± 10%; 50/60 Hz ± 1%,
max. Ri = 0.6 Ω or 200 - 240 V AC ± 10%; 50/60 Hz ± 1%, max. Ri = 2.5 Ω

Power consumption:

max. 1.3 kVA

Output:

30 kW at 96 kV, 10 ms

20 kW at 102 kV, 100 ms according to IEC 601-2-7

kV range:

40 - 133 kV in 25 steps or 49 steps

mAs range:

0.5 - 360 mAs in 58 steps (Battery operation)

0.5 - 50 mAs in 41 steps (Mains power Operation)

Shortest exposure time:

1 ms

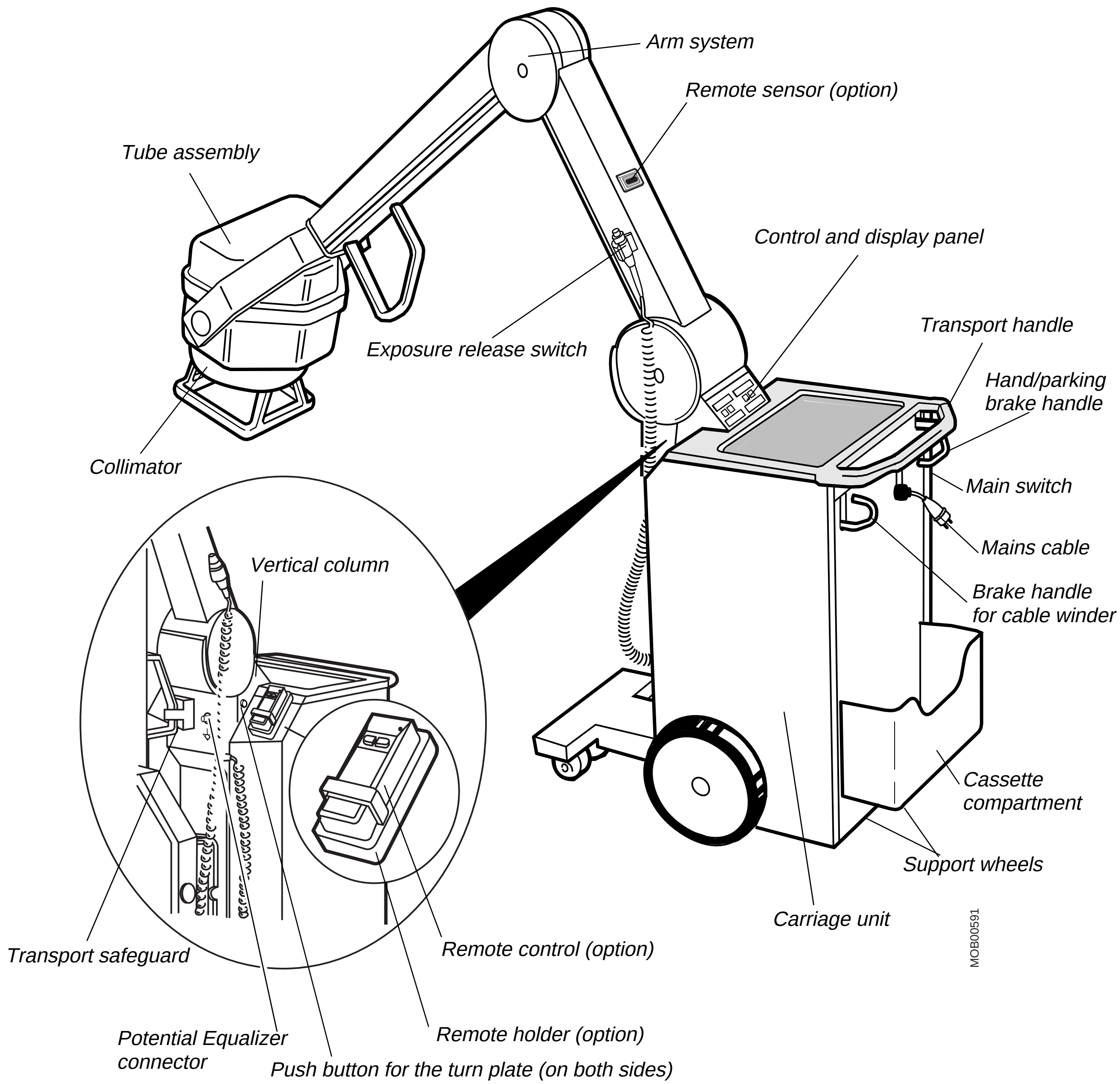
Weight:

approx. 295 kg (650 lbs.)

Batteries:

16 sealed maintenance-free lead batteries,
Sonnenschein: A512/10 S

General description



Motor driving controls and main switch

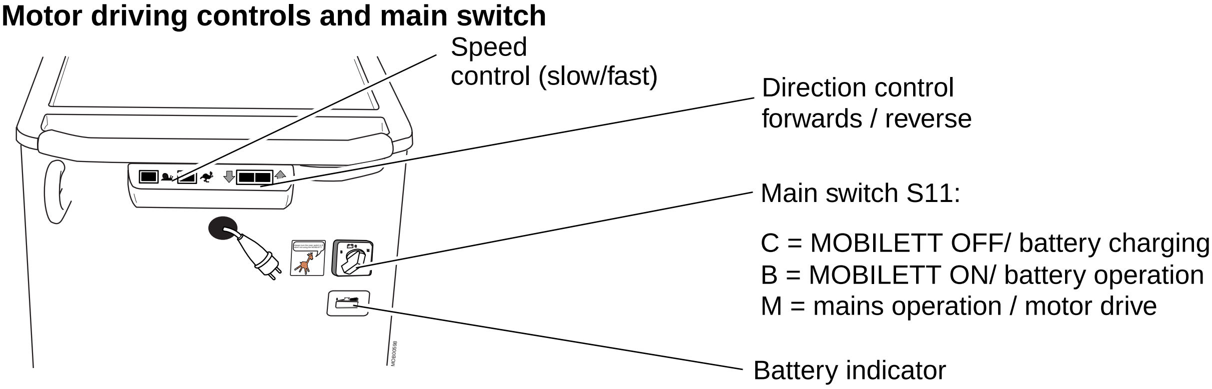


Fig. 1

The MOBILETT Plus HP (2) is equipped with a double articulated arm system. The tube assembly is adjustable in the vertical and radial direction. The flexibility of the articulated arm is the result of a linkage and articulation system. The stability of the articulated arm and tube assembly position is due to adjustable frictional forces in the joints.

The articulated arm must be positioned and locked in the transport safeguard during transport and parking.

A solenoid actuated turn plate simplifies the central beam setting and positioning. The unit can be rotated manually around its own axis. The position of the articulated arm and tube can be changed without moving the whole unit.

The multileaf collimator has a pull out measuring tape and manual adjustable collimator leaves to limit the X-ray field to patient and film. These two features contribute to user-friendly operation.

The potential equalizer (Fig. 1) can be connected to a protective earth terminal with the potential equalizer connector found next to the transport safeguard. This ensures that the MOBILETT has the same electrical potential as other units connected to the same protective earth terminal.

Furthermore there is a cable winder which pulls back the mains cable automatically if the left handle is moved.

The main switch S11 allows three different working conditions (2).

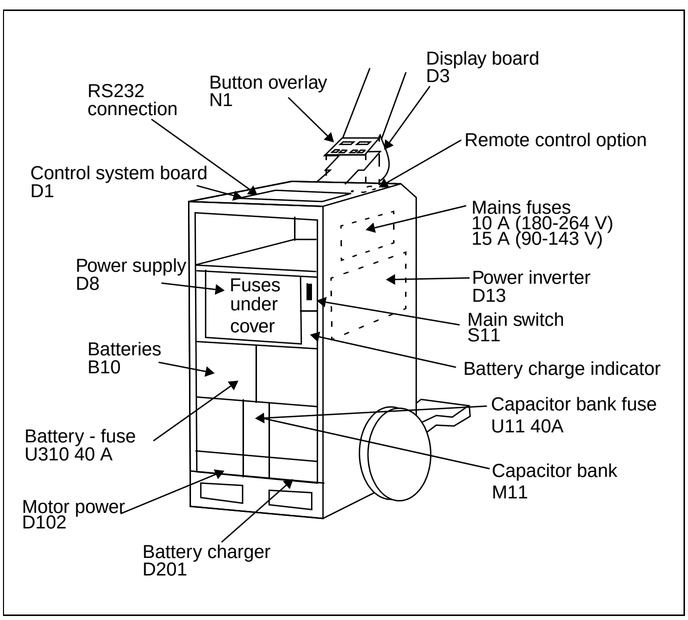


Fig. 2

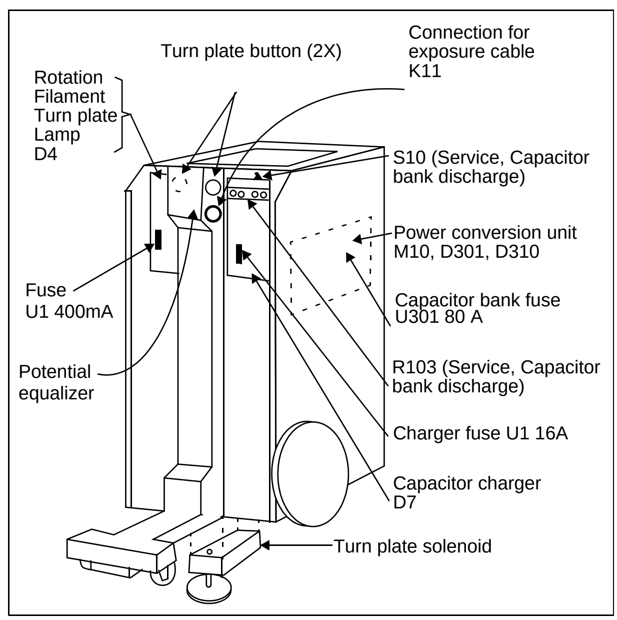


Fig. 3

Fig. 2 and Fig. 3 show the location of different components, fuses and cable connections.

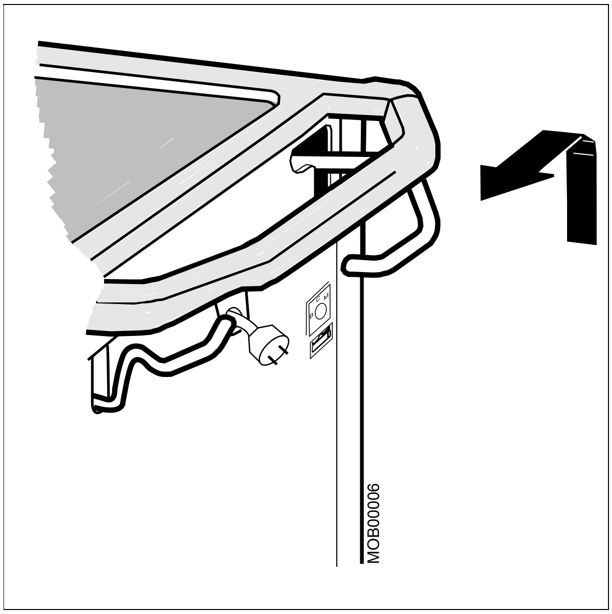


Fig. 4

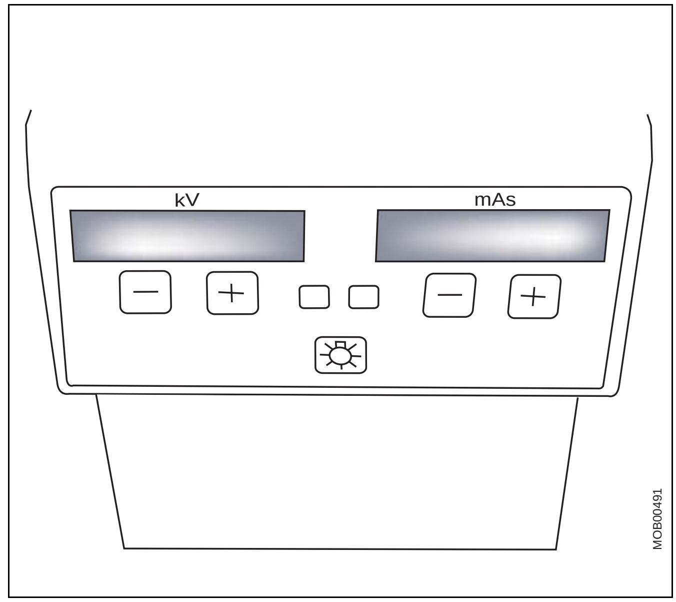
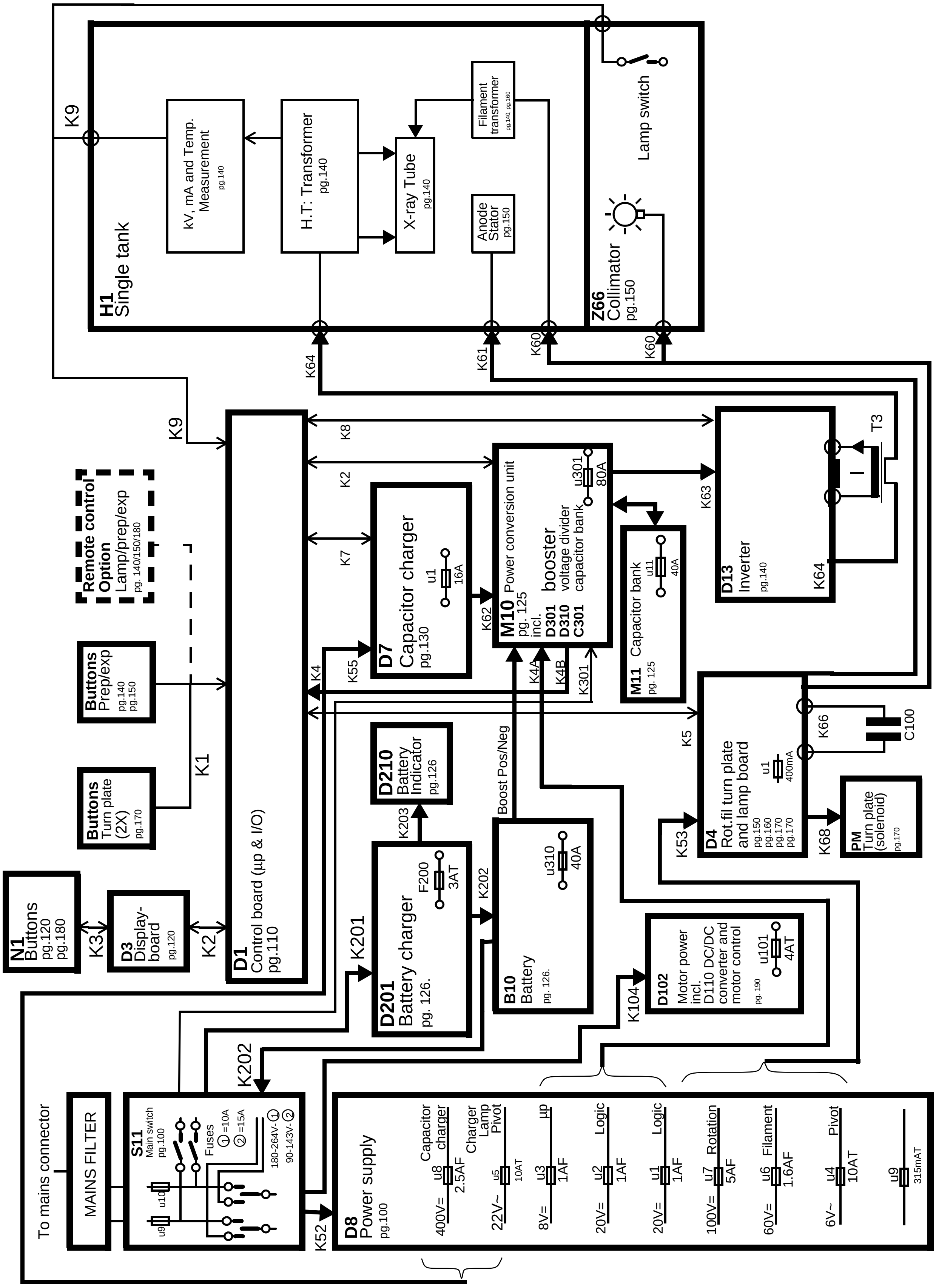


Fig. 5

The hand brake (Fig. 4) can be used during transport and for safe parking of the unit.

The display with selector buttons and the audiovisual signals simplify the use of the unit for both medical and technical staff (Fig. 5).

The Instructions for Use describe the correct operation of the MOBILETT Plus HP.



Note: Page-numbers refer to the wiring diagram

Fig. 1

The block diagram gives an overview about all PCBs and various electrical components. Furthermore it shows cable connections and fuse locations (Fig. 1).

In the upper left area the mains voltage passes through the mains filter and connects to the main switch S11. The S11 switch supplies mains or battery power to the D8 board.

The mains power is fused by U9/U10.

The double fusing of a single phase covers all safety regulations worldwide.

This ensures that each short circuit results in at least one blown fuse.

If the switch S11 is in position “C” and the mains cable is connected, the batteries are charged by the battery charger. The battery indicator shows the charging level (voltage) that is reached.

The position “M” of the switch S11 delivers the battery voltage to the motor power board D102.

All other boards and components are supplied from board D8.

The CPU board D1 controls all buttons, the display board and the lamp switch in the collimator. Furthermore the CPU (D1) regulates and monitors the conditions in D4, D7, D13, M10 and M11.

An SAB 80C535 8 bit processor is used as the main processor. This implements the user interface and supervises most of the non-time critical signals.

An SAB 80C166 16 bit microprocessor is used for the supervision of real-time tasks during exposure, such as parameter regulation and monitoring, and for tube current integration to provide the mAs.

The D4 in the lower section of the diagram supplies the turn plate below, and in the single tank on the right, the anode starter, filament transformer and the lamp in the collimator with power.

The capacitor charger D7 charges the capacitors of the power conversion unit M10 and M11.

The booster D301 adapts the battery voltage to the capacitor voltage.

The inverter D13 delivers the capacitor/battery power via T3 to the single tank on the right.

Other parts in the single tank are the HT transformer, the X-ray tube and the kV, mA and temperature measurement.

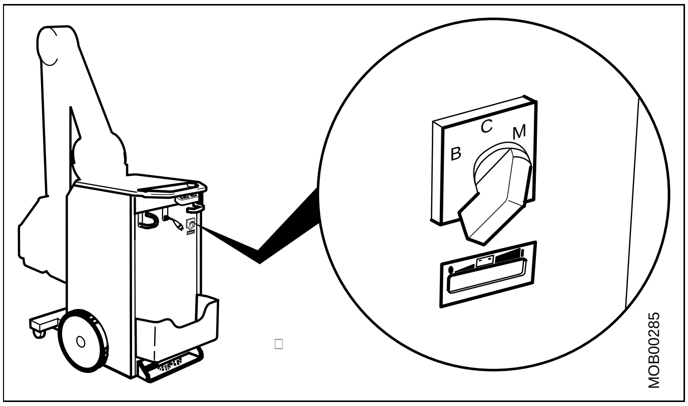


Fig. 1

The block diagrams and the wiring diagram SPR8-220.051..., sheet 100, are the basis of the functional description given below.

The unit can be connected to a grounded wall outlet with the mains cable.

The main switch S11 is used to operate the unit under three different conditions.

There are three switch positions for the three different conditions (Fig. 1).

M = mains operation / motor drive

B = MOBILETT ON/ battery operation

C = MOBILETT OFF/ battery charging

NOTE	**If the switch S11 is in position “B”, the unit can be operated without being connected to the line. In this case the power comes only from the batteries. With charged batteries the capacity should be sufficient to last one day (8 hours).**

The overview of board D8 shows the power distribution inside the unit.

Switching to position M or B provides battery or line voltage to transformer T3 on D8.

The internal power is supplied by transformer T3 on D8.

A total of nine secondary windings are available for AC voltages:

- Six are fed as DC voltages to the voltage stabilization circuits on boards D1, D3, D4, D7, D13 and D301 as supply voltages.

  They are transformed into the supply voltages required and indicated via the LED’s on these boards.

  The voltages can be checked at the test points with a digital voltmeter or an oscilloscope.

- Two are used as AC control voltages for the turn plates, one also serves as a control voltage for the collimator lamp in the multileaf collimator Z66.
- One of these secondary voltages is used as an internal supply voltage for board D8 itself.
- LED´s on all boards indicate whether voltage is present or not.

This page intentionally left blank.

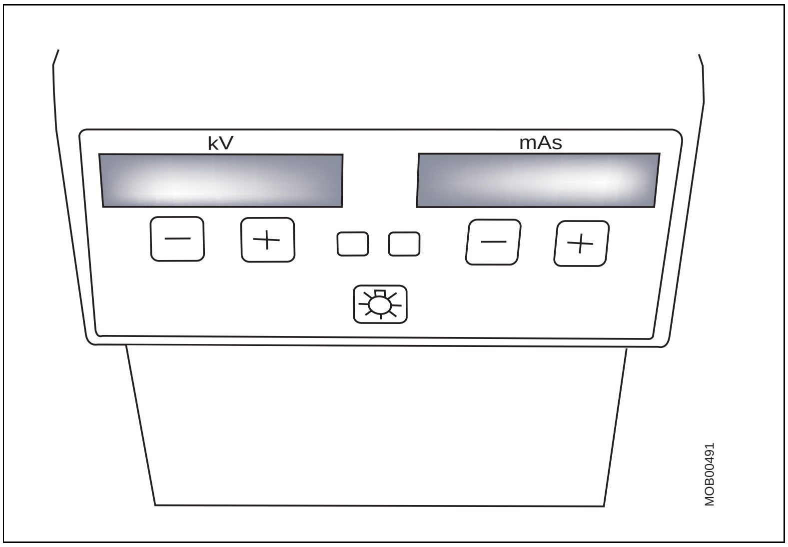


Fig. 1

Board D8 is supplied with battery voltage if the main switch (S11) is in position “B”. In position “M” the voltage for the board D8 comes from the mains.

⚠CAUTION

If the main switch is left in position B, the MOBILETT will soon be out of battery power.

Leaving the switch in position B for a long period of time may also shorten the battery life considerably.

Turn the main switch to “C” when the MOBILETT Plus HP is not being used.

If D8 is getting power, the red “reset” LED on board D1 lights up briefly. This is followed by initialization, including the self-test of the CPU.

During this phase of approx. 1s, the display on the control panel stays off.

The red “Start Up” LED on board D3 on the right inside the kV display is illuminated.

The sequence continues as follows:

- the filament circuit on board D4 turns on preheating for the filament in the single tank
- a braking cycle is executed for the rotating anode
- the exposure parameter display on board D3 becomes active (Fig. 1)

After the initial message “HEJ” “HEJ”, the last setting of exposure parameters is displayed.

- The capacitor bank is charged (see chapter 8 Charging Circuit for the Capacitor Bank).
- The oil temperature in the single tank is monitored. If the temperature is not within the range + 8 °C to + 50 °C, an error will be generated and displayed.

- The positions of the service switches “S1” and “S2” are tested by the CPU on board D1.

The switch positions are:

“S1” and “S2”	off	=	normal mode
“S1”	on	=	service mode
“S2”	on	=	PC mode

PC mode is only used for testing procedures in the factory!

If the exposure parameter display indicates “PC mode” the selector buttons on the control panel are blocked.

- The green “ready” LED on the control panel turns on as soon as the charging process of the capacitor bank is completed. This can take between 5 and 120 s.

The unit is now ready to operate!

The block diagrams and the wiring diagram SPR8-220.051..., sheet 126, are the basis of the functional description given below.

The battery circuit consists of the battery charger (D201) and the battery indicator (D210). The 4 battery banks are located in B10. All 16 batteries are sealed and maintenance free. While the battery is charging, the battery indicator shows 10 charging conditions of the batteries on 10 LED’s. If the left outmost LED is flashing, the batteries are nearly empty (battery voltage has dropped down to approx. 200 VDC). When the right outmost LED stops flashing and becomes steady, the batteries are fully charged (battery voltage is approx. 220 VDC).

Recharging the set of 16 batteries

NOTE	**In order to charge the batteries, the unit must be connected to the mains. The main switch must be turned into position “C” (battery charging).**

The D201 is supplied from the mains. The AC power is rectified and fed to a circuit that consists mainly of a half bridge forward converter, transformer and diodes. This circuit controls the power supply to the batteries.

For batteries that are completely or nearly empty, battery charging starts with a 1.9 A constant current. The charging process is indicated by a flashing of one of the LED’s on the battery indicator. When the battery voltage level comes close to 220.8 VDC, the battery indicator right outmost LED is flashing. At this point the charging current begins to decrease. When the current has dropped down to 0.17 A, the battery charger sets a voltage level of 216 VDC for standby charging. At the same time, the right outmost battery indicator LED stops
flashing and becomes steady, which indicates that the batteries are fully charged. The whole charging procedure (for completely discharged batteries) takes about 6 hours.

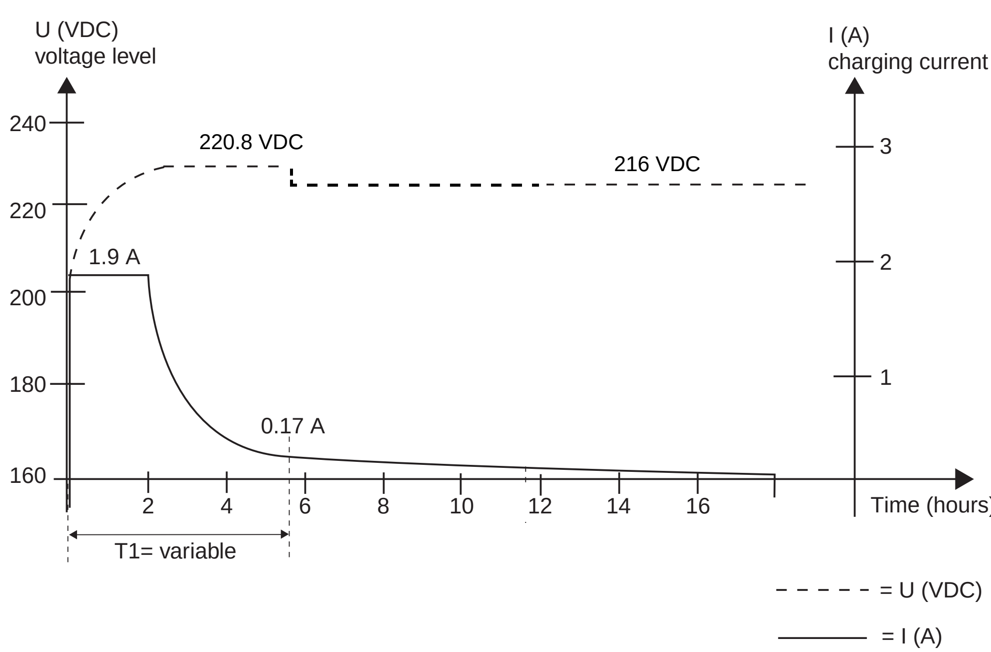


Fig. 1 Battery charger

When the MOBILETT is disconnected from the mains, and standby charging is interrupted, the battery voltage drops from 216 VDC to about 205-210 VDC within 10-60 minutes.

NOTE	**If fuse F200 on board D201 is blown there is no indication!**

Battery life

Always turn the main switch to position C when the MOBILETT is not being used. The batteries may be damaged if the main switch is left in position B for a long period of time (for instance over the weekend).

If the MOBILETT is left disconnected from the mains, batteries may be damaged after a period of 4-6 months even though the main switch is in position C. This risk is increased if the storage temperature exceeds 20°C and if the batteries are not fully charged at the beginning of the storage period.

To extend the battery life, it is recommended that the batteries are always charged until full, that is until the battery indicator stops flashing.

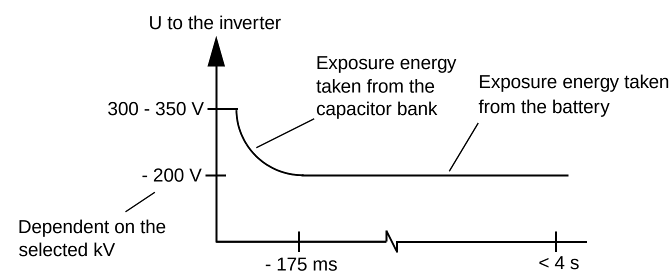


Fig. 1 Exposure energy, battery operation

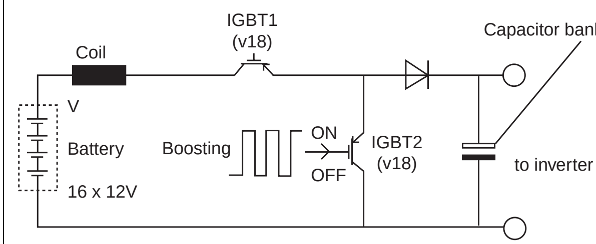


Fig. 2

The block diagram and the wiring diagram SPR8-220.051... are the basis of the functional description given below.

The power conversion unit M10 consists of the booster (D301), the voltage divider (D310), the capacitor bank (C301)and one external additional capacitor bank (M11).

During a battery exposure, the power to the inverter (D13) is initially taken from the capacitor bank (Fig. 1). When the capacitor voltage has dropped to battery voltage level, the power will be taken from the batteries and the input voltage to the inverter will be kept constant at battery level. Since the input voltage to the inverter is kept constant, the tube current will also be held at a constant level.

At kV settings below 63 kV the booster will work only as a switch and open between the capacitor and the battery when the exposure starts. I.e. IGBT1 opens during the exposure and the boosting IGBT2 is closed (Fig. 2).

At kV settings between 63 kV and 90 kV the battery voltage must be increased to ensure an exposure time of less than 4 seconds. In this case IGBT1 opens and IGBT2 is pulsed. Thus the battery voltage is increased to a proper level. In this way the exposure time can be kept constant and stay below the maximum time of 4 s.

At kV settings above 90 kV the battery voltage is too low to increase the exposure energy. The booster is then turned off and the exposure energy is taken from the capacitor bank only.

The communication between the CPU board and the booster on K2 consists of start and stop signals for the exposure as well as information about selected kV and battery voltage level.

Voltage dividers on board D310 are used together with the monitoring circuits in the booster and on the CPU board to check the present voltage levels in the capacitor bank and in the batteries.

NOTICE	**The booster function is blocked if the capacitor voltage < battery voltage, for example, if the service switch is in discharge position. The booster will become available again as soon as the capacitor bank has been recharged.** **Error message USE 39 indicates that the battery voltage is too low! In this case, charge the batteries.**

The block diagrams and the wiring diagram SPR8-220.051..., sheet 130, are the basis of the functional description given below.

The entire charging circuit consists of the boards D8, D1 and D7 and the capacitor bank in M10 and M11.

The capacitor banks consists of one module with 6 capacitors and one additional module with 2 capacitors (M11). Each single capacitor has 16 mF, 360 V.
The total nominal capacitance is 128 mF.

On board D7 three signals control the charging of the capacitor banks, M10 and M11.

“CHARGE HIGH” for charging under high load conditions.

“CHARGE LOW” for maintaining the voltage level of the capacitor banks M10 and M11, which depends on the selected kV value.

“DISCHARGE” to control the discharging of the capacitor banks, M10 and M11.

The voltage level of the capacitor bank can be checked with a voltmeter on test points “CAPPOS” and “CAPNEG” of board D7.

The voltage of the capacitor bank is monitored as the signal “CAPVOL” on the CPU board D1.

The “CAPVOL” signal determines the following control signals:

- “CHARGE HIGH”
- “CHARGE LOW” and
- “DISCHARGE”
- “READY” (used to turn on the green LED on the control and display panel)

As soon as the unit is turned on and the self-test including the initialization phase are completed. The charging process in the capacitor banks M10 and M11 starts with the control signal “CHARGE HIGH”.

This signal is controlled from the CPU on D1 and is used on board D7. Board D7 generates control pulses to drive a buck converter which supplies the capacitor bank with power. The voltage level is regulated with pulse width modulation.

If the voltage level on the capacitor bank is < 10 V, the charging process follows steps 1 to 3 described below.
If the initial voltage is > 10 V only step 3 will be executed.

- Step 1 Charges the capacitor bank to approx. 150 V.
- Step 2 Turns off the signal “CHARGE HIGH” and checks whether the voltage level of 150 V can be kept constant for at least 5 s, for monitoring and measuring.
- Step 3 Turns on the “CHARGE HIGH” signal again and completes the charging procedure.

After the charging process has been completed, a regulation circuit tries to maintain the voltage level just reached.

The following three voltage levels, which depend on the selected kV range, are possible:

A, 300 V with a tube voltage < 45 kV

B, 325 V with a tube voltage $\geq$ 45 kV and < 50 kV

C, 350 V with a tube voltage $\geq$ 50 kV

The drop in the capacitor voltage, which may take place during the 5 s pause in phase 2, is a measure of the leakage current of the capacitor bank. If the drop is too large, the control signal “DISCHARGE” is switched on and an error message is shown on the display.

As long as the capacitor bank is being charged with “CHARGE HIGH”, the microprocessor on board D1 cannot switch on any other major power consuming device, such as the collimator lamp or the turn plate. However, if this is required, the operating personnel can request this via a manual switch-on procedure. In this case, the microprocessor on the CPU board D1 interrupts the charging procedure. “CHARGE HIGH” is then switched off for the duration of the new routine.

When the high-power consuming device is switched off again, the charging process will continue with the signal “CHARGE HIGH”.

In the final phase of the charging process, the actual value of the capacitor voltage “CAP VOL” on the CPU board D1 is monitored via a software-controlled window discriminator.

When the actual value exceeds the threshold voltage of Uc - 0.8 V, the signal “CHARGE HIGH” is switched off and the green “ready” LED on the control and display panel is turned on (Fig. 1).

The signal “CHARGE LOW” is then switched on. This regulates the actual value of the capacitor voltage “CAP VOL “ with a low charging current up to the desired final value. “CAPVOL” will then be held at, or slightly above, the reference value by switching off and switching on “CHARGE LOW”.

The “ready” lamp remains turned on as long as the actual value of the capacitor voltage “CAP VOL” remains within the hysteresis tolerance range of ± 1.2 V (Fig. 1).

If the capacitor voltage “CAP VOL” is not within the threshold voltage range of ± 1.2 V, for example, due to an unusual large leakage current or another kV selection, the green “ready” LED on the control and display panel will be turned off.

The capacitor is then either charged with “CHARGE HIGH” or discharged with “DISCHARGE” as required until the actual voltage value “CAP VOL” of the capacitor bank is within the tolerance range of ± 0.8 V.

The green “ready” LED on the control and display panel is then turned on again.

The unit is ready to operate!

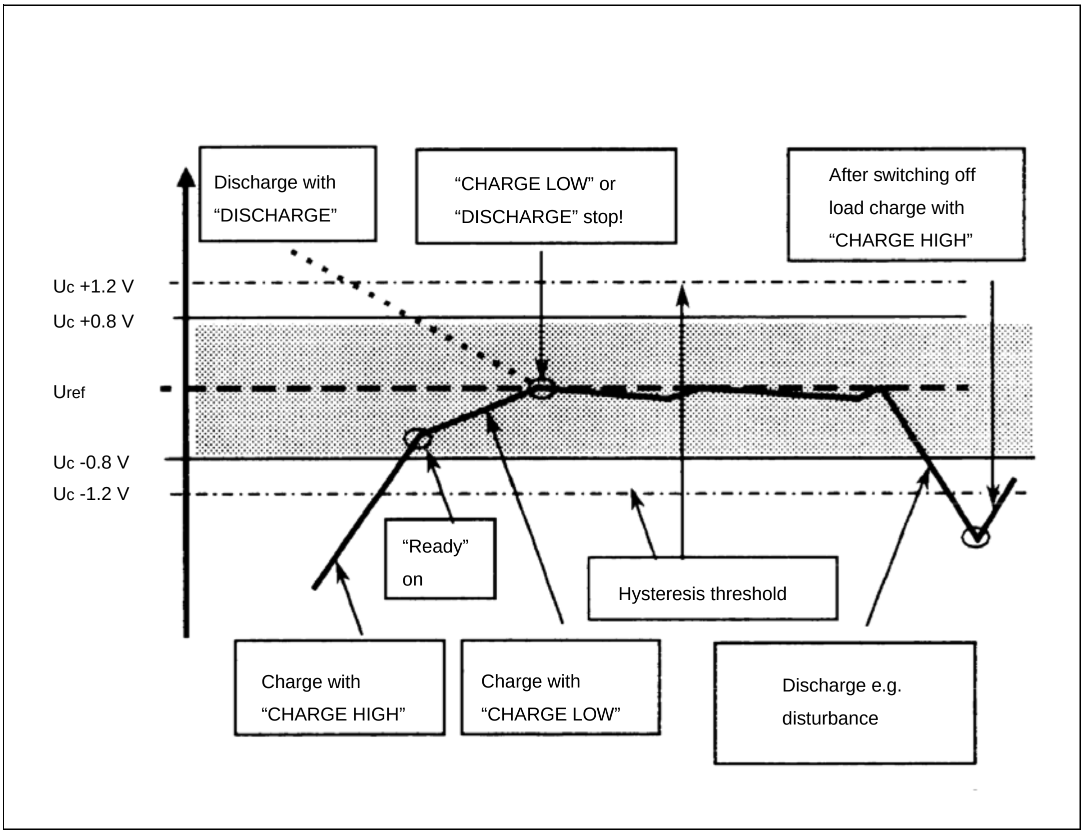

Discharge with
"DISCHARGE"
"CHARGE LOW" or
"DISCHARGE" stop!
After switching off
load charge with
"CHARGE HIGH"
Uc +1.2 V
Uc +0.8 V
Uref
Uc -0.8 V
Uc -1.2 V
"Ready"
on
Hysteresis threshold
Charge with
"CHARGE HIGH"
Charge with
"CHARGE LOW"
Discharge e.g.
disturbance

Fig. 1

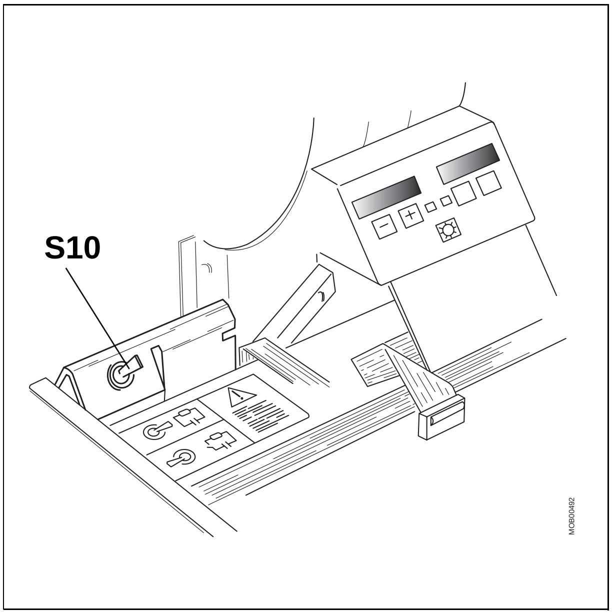


Fig. 2

Servicing the charging circuit

⚠DANGER	**High voltage!** **DANGER TO LIFE!** **Comply with the safety information and protective measures in chapter 1.**

NOTICE	**The discharge procedure can be initiated manually with service switch “S10” independently of whether the unit is switched on or off.** **For safety reasons, the capacitor banks must always discharged before any service procedure is started on these capacitors or in the charging circuit!**

Closing this switch initiates discharge with a limited discharge current via a resistor pair - including the two resistors R100 + R 101.

It is advisable that you connect a digital voltmeter to test points “CAP POS” and “CAP NEG” on board D7 to monitor the discharge process.

⚠WARNING	**Risk of high voltage!** **RISKS CAN ONLY BE EXCLUDED IF THE VOLTAGE DROPS TO BELOW 3 VOLTS !** **After this it is safe to perform service tasks in the charging circuit or in the capacitor banks.**

⚠WARNING	**High voltage!** **If the batteries are connected, there is a hazard of life-threatening electric shock.** **Disconnect the batteries by removing one of the “KBATT” plugs (see chapter 1).**

When replacing the capacitor bank or after a shutdown time of several months, it is necessary to “form” the capacitor bank. This prevents a premature capacitor defect.

For this, the service program “P06 Capacitor Formation” can be used.

The Service Instructions describes how to call up this service program.

Errors in the charging circuits

Any error occurring in the charging circuit or in the capacitor bank leads to the following sequence of action:

- the buzzer on board D3 generates 10 beep tones
- the green ready LED is switched off
- the exposure data disappear in the parameter display
- discharging of the capacitor bank starts automatically with the “DISCHARGE” signal and an error message appears in the parameter display.

The discharge procedure for the capacitor bank continues until the indicated error is switched off by pressing the selector button “kV+” or by switching the unit off and on.
In addition to the software-controlled monitoring for the signal “CAP VOL” on the CPU board D1, there is a hardware monitoring circuit on board D7.

This compares the potential difference across the capacitor bank.

The potential difference between test points “CAP POS” and “CAP NEG” is fed via a differential amplifier to a comparator. The output voltage from the differential amplifier is compared to a threshold value of 360 V.

If the output voltage of the differential amplifier exceeds the threshold value, the signal “OVERVOLTAGE” will be generated and the LED V12 on board D7 will be lit.

Via the CPU on D1, the “OVERVOLTAGE” signal starts the sequence of action described above to protect the entire capacitor bank.

Other error messages are:

- Voltage rise in capacitor bank too fast,
- Voltage rise in capacitor bank too slow, or
- too much leakage current in the capacitor bank.

This page intentionally left blank.

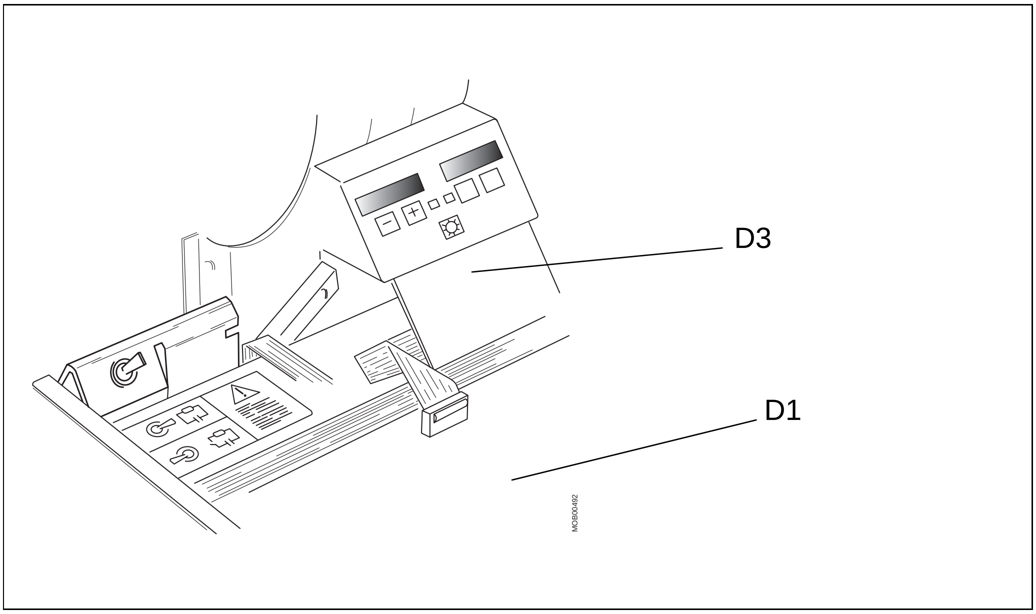


Fig. 1

The block diagrams and the wiring diagram SPR8-220.051..., sheet 120, are the basis of the functional description given below.

The control circuit for selecting the exposure parameters consists of boards D1, D3 and the control and display panel (Fig. 1).

The kV value is selected with the kV selector buttons “kV+” and “kV-” on N1.

There are different options for parameter selection:

A 25 individual steps from 40 - 133 kV in whole exposure points.
or

B 49 individual steps from 40 - 133 kV in half exposure points.

The desired option is set in service program P14.

The service program P14 also allows you to determine the maximum selectable kV value between 40 - 133 kV.

The mAs value is selected with the mAs selector buttons “mAs+” and “mAs-” on N1.

The maximum selectable mAs value is set up with the service program P15 and appears in the parameter display. Two mAs ranges are possible:

A. 0.5 - 360 mAs for battery operation

B. 0.5 - 50 mAs if only main supply.

The mAs range selection starts at a minimum of 0.5 mAs. The maximum of 360 mAs may not always be reached because it also depends on the chosen kV value.

Please refer to the Service Instructions on how to select the service program P14 or P15.

The selected exposure parameters are shown on the display of the control and display panel.

A permanent pressing of a selector button increments or decrements the exposure parameters, first slowly, then faster.

Reaching the minimum or maximum values automatically blocks the selection for kV and mAs values.

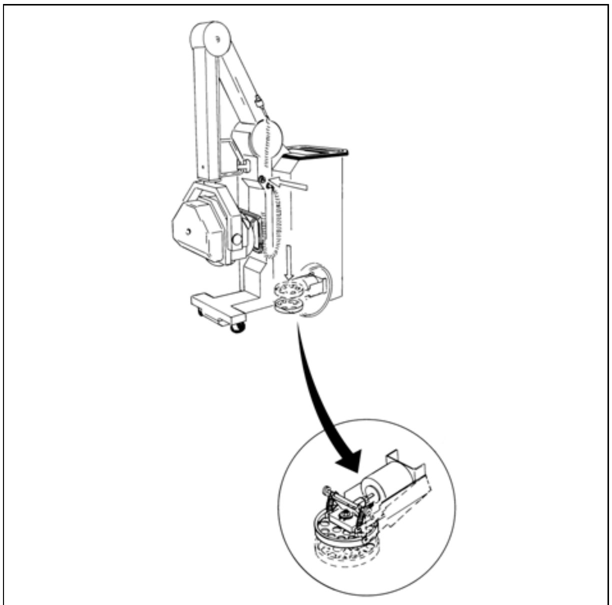


Fig. 1

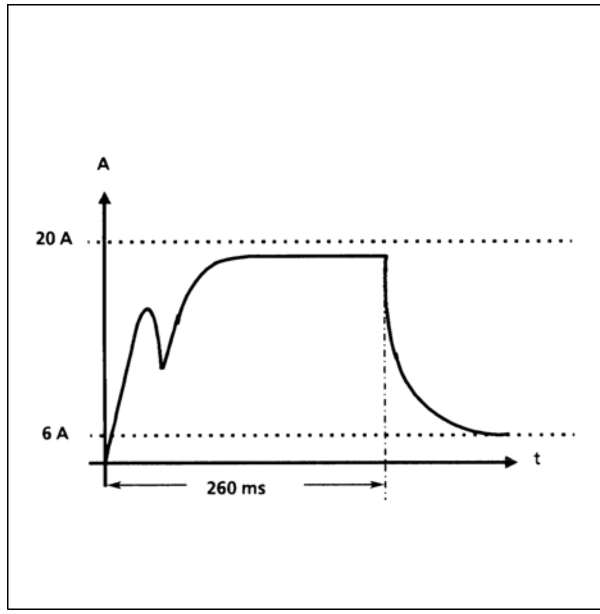


Fig. 2

The block diagrams and the wiring diagram SPR8-220.051..., sheet 170, are the basis of the functional description given below.

The turn plate control circuit consists of the boards D8, D1 and D4 and the turn plate solenoid PM itself.

The turn plate solenoid is driven by the two signals “PIVOT ON” and “PIVOT HOLD”.

Both signals can be measured on board D4.

The turn plate can be switched by the two turn plate buttons (S30 + S31), located on the left and right side of the vertical column.

Pressing one of the buttons generates the control signal “PIVOT ON”. A lamp in both control buttons indicates the “ON” condition of the solenoid.

If you reactivate one of the two buttons, the solenoid and the lamps are switched off.

The signal “PIVOT ON” turns on the relay MR1 on board D4, which connects an AC voltage from board D8 to a rectifier on board D4.

This supplies the solenoid coil with a DC-PWR of + 23.5 V. A high current surge of approx. 20 A turns on the turn plate solenoid.

By means of a system of levers and springs, the magnetic force presses the turn plate which is located beneath the generator towards the floor.

After this the CPU changes the signal condition from “PIVOT ON” off to “PIVOT HOLD” on! This is necessary to reduce the current from the line power and to keep the present mechanical position.

The MR1 returns back to its previous position and MR2 turns on.

This supplies the turn plate solenoid coil (Fig. 1) with a reduced power of about 8 VDC.

The magnetic force in the turn plate solenoid is somewhat greater than the opposing forces in the turn plate's system of levers and springs. This holds the turn plate in the achieved position.

The magnetization current surge (Fig. 2) that occurs in the solenoid coil when turning on the relay MR1 with the signal “PIVOT ON” can be measured with a current probe in cable K 68.

The block diagrams and the wiring diagram SPR8-220.051..., sheet 180, are the basis of the functional description given below.

The control circuit for the halogen collimator lamp in the multileaf collimator consists of the button panel N1, the boards D3, D1, D8 and D4 and the multileaf collimator Z66.

The collimator lamp is activated by two switches.

- one switch is located directly on the multileaf collimator,
- the other switch is on the control and display panel N1.

The signals from the two switches are independently controlled by the CPU on board D1.

If one of the switches is pressed, the CPU on board D1 generates the signal "LAMP ON" for the relay "LR1" on board D4. This signal can be measured on board D4 at test point "LAMP ON".

With relay "LR1" turned on, an AC voltage of approx. 22 V is supplied to the collimator lamp. These are the same 22 V to supply the turn plate circuit.

⚠CAUTION

If the collimator lamp is switched on while charging the capacitor banks M10 and M11 before the signal "CHARGE HIGH" appears, the charging procedure is interrupted for approx. 1 sec.

After this time the filament current of the collimator lamp is low enough to avoid a loss of fuse U5 on D8!

There are three possibilities to turn off the collimator lamp:

- manually by all both switches
- automatically at exposure
- or after a time of 30 s via the CPU on D1.

This page intentionally left blank.

The block diagrams and the wiring diagram SPR8-220.051..., sheets 120, 130, 140, 150 and 160, are the basis of the functional description given below.

With turning the unit on, initialization takes place. Charging up the capacitor bank in M10 and M11 will follow if the main switch was set to pos. “M”. After that the green “ready” LED turns on and allows you to use of the unit. Now the exposure parameters can be chosen with the selector buttons “±kV” and “±mAs”.
The X-ray field must be focused to the object with the multileaf collimator.
After that the exposure described in below can be performed.

Exposure preparation

The pre-contact in the exposure release switch closes first.This enables the following functions:

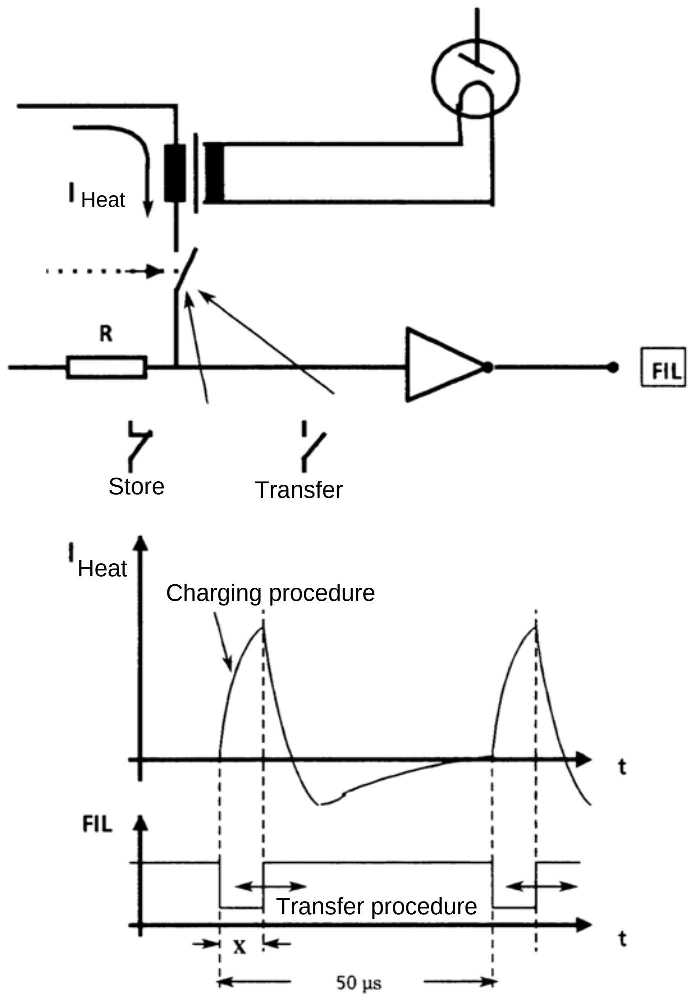
- switches the filament current from preheating to exposure heating
- starts the run-up time of 2 s for the rotating anode
- generates three beeps if preparation is completed with the “anode up to speed” message
- at the same time the green “ready” LED which is off at the start of preparation turns on again.

Exposure release

The main contact in the exposure release switch closes. This is finally the start of radiation with the following functions:

- the yellow exposure indicator lamp lights up and the exposure start signal turns on the kV inverter
- the selected kV value and the calculated tube current will be generated.
- as soon as the selected mAs value is reached, the exposure is terminated by instantly switching off the kV inverter
- the yellow exposure indicator lamp switches off and a long beep signals the end of exposure
- the filament current is switched back to preheating and the braking mode brings the anode to a full stop.

This page intentionally left blank.



Pulse width x = approx. 6 µs in “stand by mode”
Pulse width x = approx. 20 - 30 µs in “preparation or release mode”

Fig. 1

The block diagrams and the wiring diagram SPR8-220.051..., sheet 160, are the basis of the functional description given below.

The filament circuit consists of boards D1, D4 and D8 and the single tank H1.

The power of the filament heating in the X-ray tube is controlled by pulse width modulation.

This is based on charging a heating transformer over a variable time “X” and then transferring the energy to the filament (Fig. 1).

The principle is based on charging the primary side of the heating transformer if the switch is closed.

When the switch opens, the electrical energy is instantly transformed from the primary to the secondary side and from there to the filament.

This pulse width modulated signal can be measured on test point “FIL” at board D4 and is used to control a MOS-FET on board D4.

The MOS-FET supplies the filament transformer with variable regulated current pulses at a constant frequency of 20 kHz.

The voltage of the current source can be measured between the test points “60 VDC” and “60 VDC RET” on board D4. The actual value of this voltage can be measured at test point “FILVOL” 1 V(D4) = 14 V (D4) on the CPU board D1.
A measuring resistor on board D4 detects the primary filament current.

The voltage drop across the resistors is fed to the CPU board D1.

The value can be measured at test point “FIL VAL” (1V $\hat{=}$ 1.5 A) at board D1 and represents IH_{actual} the real filament current.

In “standby” the filament of the X-ray tube gets “preheating”. In this mode, it is possible to measure a pulse time of 6 µs at test point “FIL” on board D4.

The actual filament current “FIL VAL” is measured and monitored every 52.5 ms by the CPU on board D1.

In “stand by” mode the signal “FIL VAL” must be in between this limit range from 0.16 V - 2.5 V.

If the value exceeds the min. or max. limit the following happens:

- the filament circuit is blocked instantly,
- the green “ready” LED on the control and display panel is switched off and
- an error message appears in the parameter display.

The change in “preparation mode” from preheating to exposure heating requires a higher current for the filament.
Therefore the pulse width for the trigger signal “FIL” on board D4 increases to a greater regulating range of 20 - 30 µs.
This pulse width can vary in that range because it also depends on the selected kV value.

The CMOS memory contains two tables with different reference values for adjusting the heating.
One table contains fixed starting values. The other one contains calibrated values which are stored during the self-adjustment of the tube.

The fixed starting values are used if no table with calibrated values is available.
Here, the fixed values are copied to the table of calibrated values.

Later on, the values for this table are changed and optimized during the adjustment to correct the wave form of the tube current.

In the preparation mode, the signal “FIL VAL” must comply with three conditions in order to avoid an error message (Fig. 2):

1. The voltage level of the signal “FIL VAL” must be within a certain tolerance range. The kV-dependent reference voltage for the filament current determines the pulse width value.
   The permitted tolerance in the filament current according to different tube types is + 0.6 V on “FIL VAL”.
2. The voltage level of the signal “FIL VAL” must be stable. The signal “FIL VAL” is checked every 13 ms during a period of 3 s. A stable value is considered to be a difference of < 0.9 V on “FIL VAL” between the first and last signal out of 20 measurements.
   The “stable” voltage value is stored in the memory as a new actual “FIL VAL”.
   The filament program now changes to “holding mode”.
3. In this mode the actual signal “FIL VAL” must remain within a tolerance of + 0.12 V to the reference value

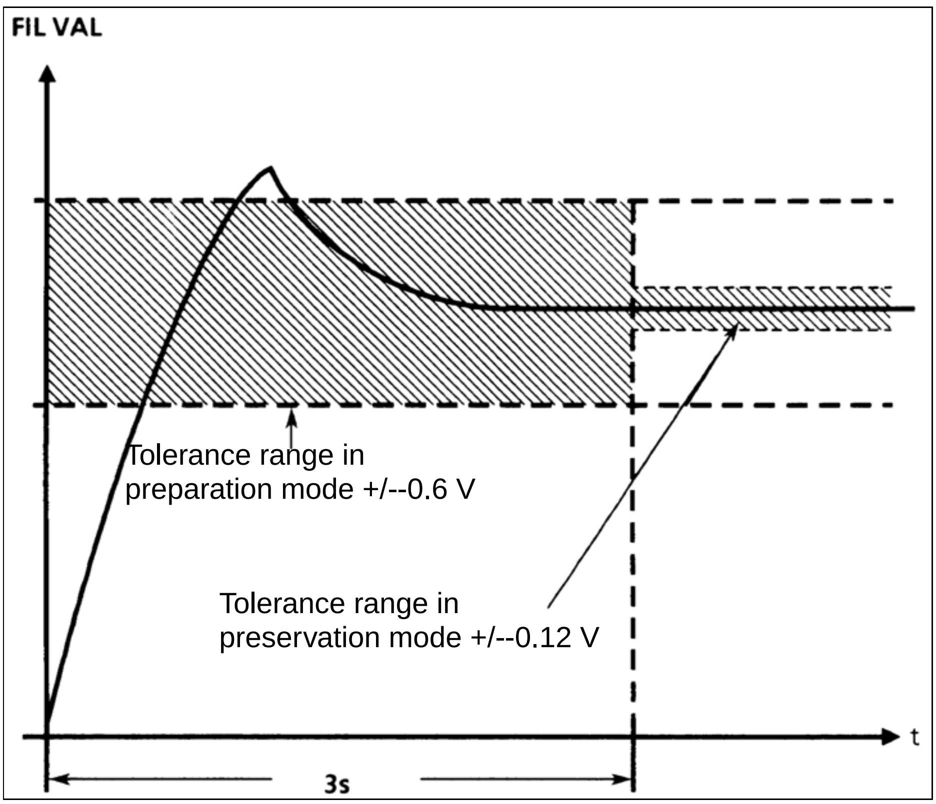


Fig. 2

Filament circuit faults

When a fault occurs in the filament circuit, the following actions take place:

- the buzzer on board D3 generates 10 beep tones
- the green “ready” LED on board D3 is switched off and the heating is also switched off
- an error message appears in the parameter display instead of the exposure data.

The error message is acknowledged by pressing the “kV+” selector button.

If this does not work, proceed according to the Service Instructions!

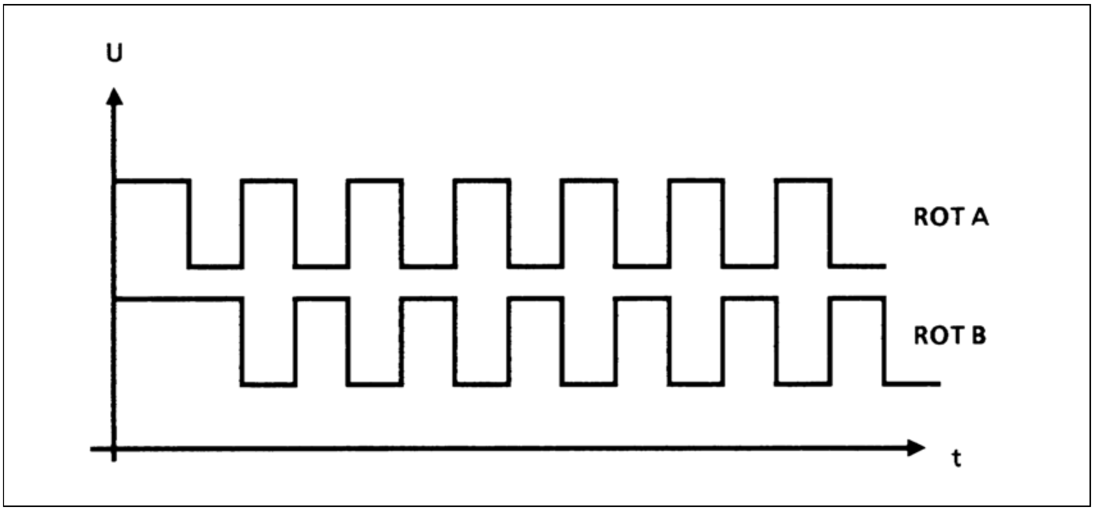


Fig. 1

The block diagrams and the wiring diagram SPR8-220.051..., sheet 150, are the basis of the functional description given below.

The circuit for the rotating anode consists of boards D1, D4 and D8 and the stator of the single-phase asynchronous motor of the rotating anode in the single tank H1.

The inverter for the rotating anode has four POWER MOS-FETs as a square wave inverter on board D4.

The inverter is supplied with 100 V DC from board D8.

This voltage can be measured between the test points “100 V DC” and “100 V DC RET” on board D4.

The inverter on board D4 is controlled by the SAB 80 C535 CPU on D1. Two180° phase-shifted signals (Fig. 1) “ROT A” and “ROT B” on board D4 generate the speed for the rotating anode with a boost of power in a time of 2 s.

The power from the inverter feeds the two windings of the single-phase asynchronous motor via the cable “K61”.

A phase-shift capacitor is in series with the auxiliary winding of the motor. The phase-shift capacitor connects via cable “K66” board D4 and the auxiliary winding of the motor.

The phase shift between main and auxiliary winding is 90°. This is necessary to enable rotation with the maximum torque.

To get the rotating anode up to speed, a control signal with a frequency of 160 Hz is applied to the two test points “ROT A” and “ROT B” on board D4.

The run-up-time requires two seconds. After this the control signal is switched off and the anode runs freely. If the anode looses speed and a frequency <147 Hz is measured, the anode is accelerated for 0.75 s. These additional “pushes” are repeated, if necessary, until the limit of the preparation time (20 s) or until the release of an exposure. A push is interrupted if an exposure signal is issued.

The free running anode motor acts like a generator. It produces a remanence voltage which is detected by a transformer on board D4.

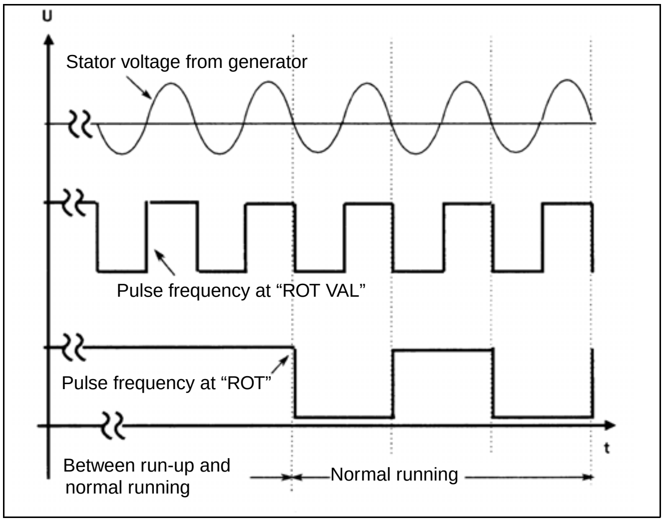


Fig. 2

The frequency of this voltage represents the current speed and it is monitored from the CPU during the entire free run. The frequency reached can be checked (Fig. 2) at “ROT VAL” on board D4 or at “ROT” on board D1.

At test point “ROT” on the CPU board D1, the time between two pulse edges is the time for a complete sinusoidal oscillation.

The pulse frequency is divided by 2 at test point “ROT” on D1. It is monitored at the same time from the CPU on D1.

The anode is up to speed if the pulse frequency “ROT” is > 147 Hz after the run-up-time of 2 s.

If the frequency detected is below 147 Hz, the entire run-up procedure will be repeated and the attained speed will be measured again.

If the second attempt indicates that the required speed of 147 Hz has now been exceeded, the control system generates the internal message “anode up to speed”! This completes the preparation together with exposure heating on.
The green “ready” LED on the control and display panel turns on and the buzzer generates three beep tones.

The unit is now ready to operate!

After the exposure has been terminated the anode-braking procedure starts. This is done with a pulse frequency of 1.667 kHz by the CPU on board D1. It can be measured on test point “ROT A” at board D4.

This frequency generates by one pair of MOS-FETs in the inverter a pulsed DC current for both stator windings.

The magnetization in the stator and rotor winding produces an eddy current field which slows down the speed of the rotor. The brake time to a full stop takes 9 s.

The braking procedure for the rotating anode is also active under the following circumstances:

- when switching on the unit,
- if the operator interrupts an exposure preparation, or
- if a system fault occurs.

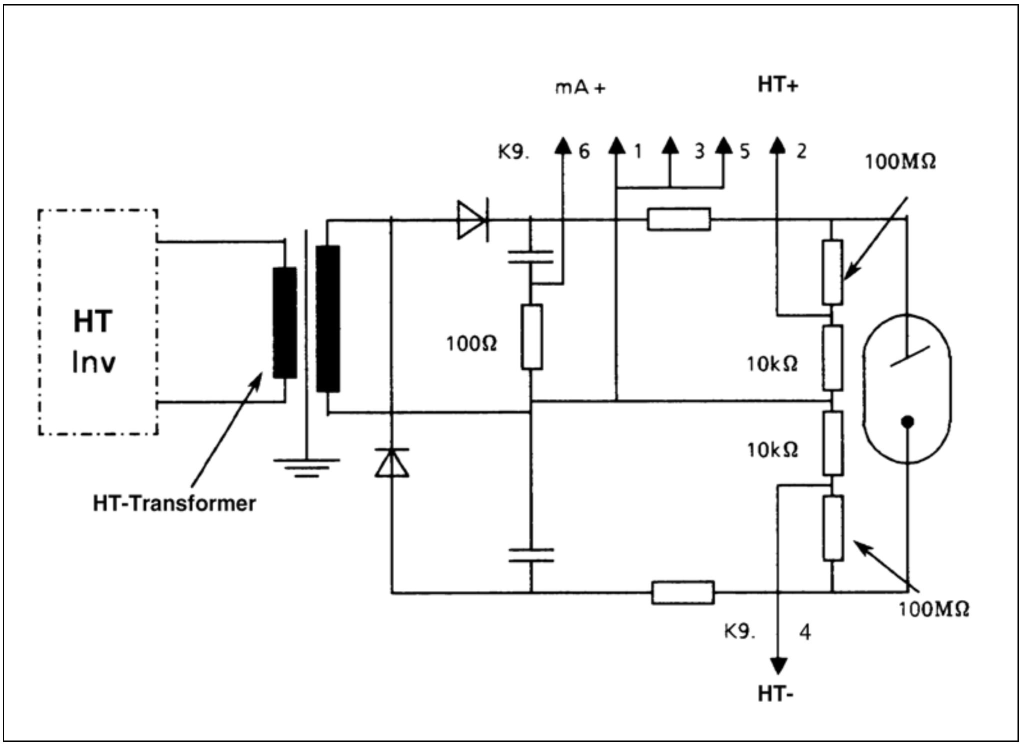


Fig. 1

The block diagrams and the wiring diagram SPR8-220.051..., sheet 140, are the basis of the functional description given below.

The high-voltage circuit consists of:

- the capacitor banks M10 and M11,
- the CPU on board D1,
- the kV inverter on board D13,
- the single tank H1.

The kV inverter on board D13 has eight power MOS-FETs and functions as a square wave inverter.

It is supplied with power from the capacitor banks M10 and M11 and control pulses of 20 - 50 kHz from CPU board D1.

These pulses can be measured at the test points “INV A” and “INV B” of board D13.

The kV inverter drives a DC voltage of alternating polarity through the primary winding (Fig. 1) of the single tank H1.

The secondary winding of the single tank H1 transforms these current pulses into a higher voltage and a voltage doubler circuit generates it up to the kV value.

At exposure start, the kV inverter on board D13 is controlled by a pulse frequency of 50 kHz.

This frequency is continuously decreased during 0.7 ms to 20 kHz, or 25 kHz (< 60 kHz). This frequency is kept for the rest of the exposure time.
The frequency scan during the exposure start is intended to limit the inverter current.

Via measuring resistors in the single tank, the actual voltage at the anode and cathode “HT+” and “HT-” are fed to the CPU board D1.

These two signals are added on a differential amplifier into the signal “HT” and a summation amplifier into the signal “HTD”.

The signal “HT” represents the total amount of kV across the X-ray tube in the single tank. It is transformed via another amplification circuit into the kV peak value of the tube “HT PEAK”.

The signal “HTD” represents the difference between the two high-voltage signals “HT POS” and “HT NEG”.

The signal levels for the high voltage are:

“HT POS”	+ 1V/10 kV
“HT NEG”	-1V/10 kV
“HT”	+ 1V/40 kV
“HTD”	± 1V/40 kV
“HT PEAK”	+ 1V/40 kV

The CPU board D1 measures the signal “HT PEAK” every 150 µs. The measured value is used as a feedback control for the tube voltage. The tube voltage depends on the pulse width modulation of the kV inverter signal and on the filament control signal.

The “HT PEAK” is checked to be within a tolerance of ± 5 kV of the reference of the selected kV value.
The signal “HTD” is checked to a limit condition of ± 20 kV.

The maximum values of the signals “HTD” and “HT” are defined as follows:

“HTD”	± 20 kV
“HT”	142 kV

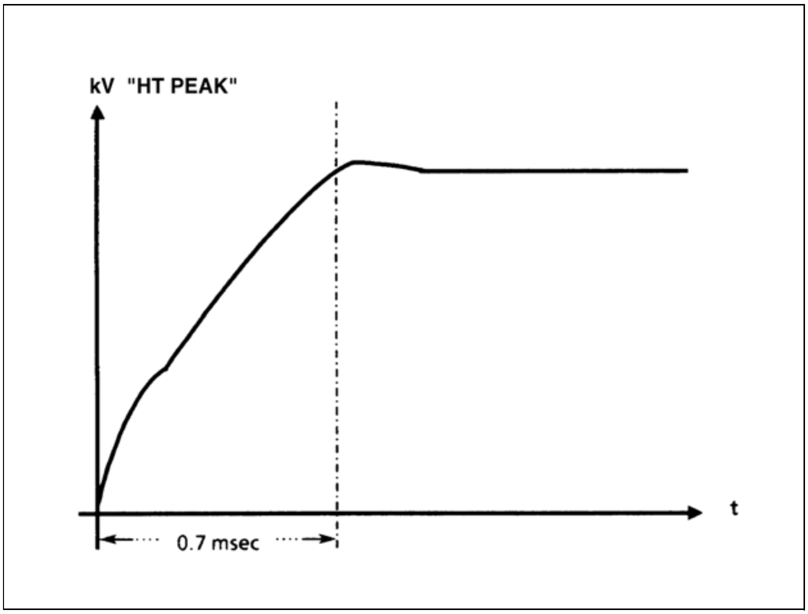


Fig. 2

High-voltage waveform “HT PEAK” for a short exposure time of approx. 2.5 ms (Fig. 2).

The current converter T3 on board D13 picks up the kV inverter current passing through the high-voltage transformer in the single tank. There it is checked by a comparator to a threshold voltage of max. 350 A.

If the current in the kV inverter exceeds this threshold value (due to a surge or a strong discharge in the tube of the single tank) the signal “OVERCURRENT” is generated at the output of the comparator.

This signal is fed to the CPU board D1, which sends out an error message.

High-voltage circuit errors

The following events in the high-voltage circuit will generate errors:

• HT PEAK	> ± 5 kV exceeds the selected kV value
• HT	> 142 kV
• HTD	> ± 20 kV
• OVERCURRENT	a kV inverter current of > 350 A

The unit reacts as follows to an error in the high-voltage circuit:

• the signals “INV A” and “INV B” are	blocked
• the green “ready” LED on the control and display panel	turns off
• the rotating anode brake mode	is activated
• the exposure heating	turns off
• the preheating	switches on, and
• the parameter display	shows an error message

The error message displayed is acknowledged by pressing the selector button “kV+”.

If the same error message reoccurs, proceed according to the Service Instructions!

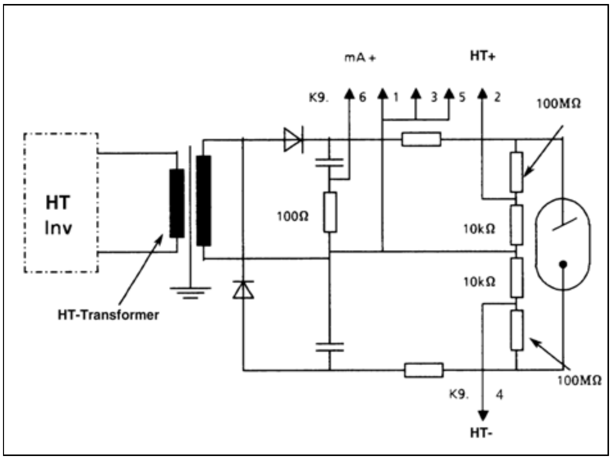


Fig. 1

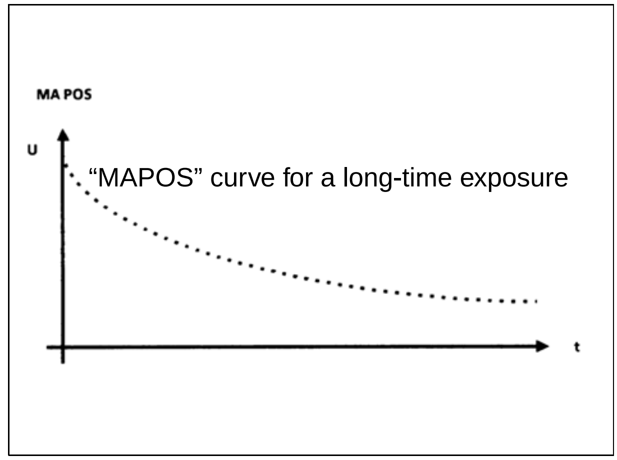


Fig. 2

The block diagrams and the wiring diagram SPR8-220.051..., sheet 140, are the basis of the functional description given below.

The actual tube current is led via a measuring resistor in the single tank and cable K9 to the CPU board D1 (Fig. 1).

It can be measured at test point "MA POS".

Before the exposure starts, the selected mAs value is stored as a reference value in an event counter.

0.7 ms after the start of exposure, the actual tube current "MA POS" is measured every 50 µs by the CPU board D1 until the exposure is terminated.

The result of the measurement is used to decrease the reference value in the counter.

Simultaneously, each measured actual tube current value is compared to a minimum value of 5 mA (Fig. 2).

The selected mAs value is reached as soon as the reference value in the counter has been reduced to zero.

Afterwards both control frequencies at test points "INV A" and "INV B" on board D13 are blocked.

This turns off the kV inverter.

The following actions are initiated:

- the yellow exposure indicator lamp is turned off,
- the buzzer on board D3 produces a relatively long beep,
- the rotating anode slows down to a full stop within about 9 seconds, and
- the green "ready" LED on the display of the control and display panel turns off.

When the anode stops, the capacitor banks M10 M11 will be recharged.

As soon as the signal "CAP VOL" has reached its kV-dependent voltage level, the green "ready" LED is turned on. The unit then can be used to start the next exposure.

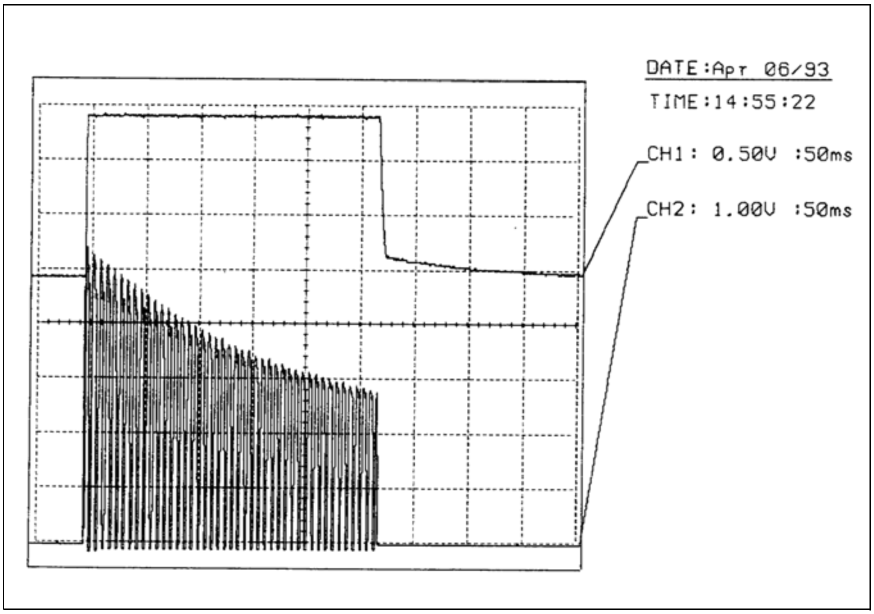


Fig. 3

The upper oscillogram shows, for example:

CH 1 = "HT PEAK" at 60 kV

CH 2 = "MA POS" at 100 mAs

Here, only the "envelope" of "MA POS" is important since, due to the "sample rate", measurements with a digital oscilloscope can easily distort the individual pulse forms shown in the display (aliasing effect)!

See the Service Instructions for more detailed information!

Errors in the tube current circuit

Whenever the CPU on board D1 detects after several consecutive measurements that the actual tube current "MA POS" is below the minimum value of 5 mA, it leads to an error message.

The unit then reacts as follows.

- the signals "INV A" and "INV B" are blocked,
- 10 beeps are generated by the buzzer on board D3,
- the yellow exposure indicator lamp is turned off,
- the exposure heating is switched off,
- the preheating is switched on,
- the rotating anode stops within 9 s,
- an error number is shown in the parameter display.

The error number is acknowledged by pressing the selection button "kV+". If the problem reoccurs when repeating the exposure, proceed according to the Service Instruction.

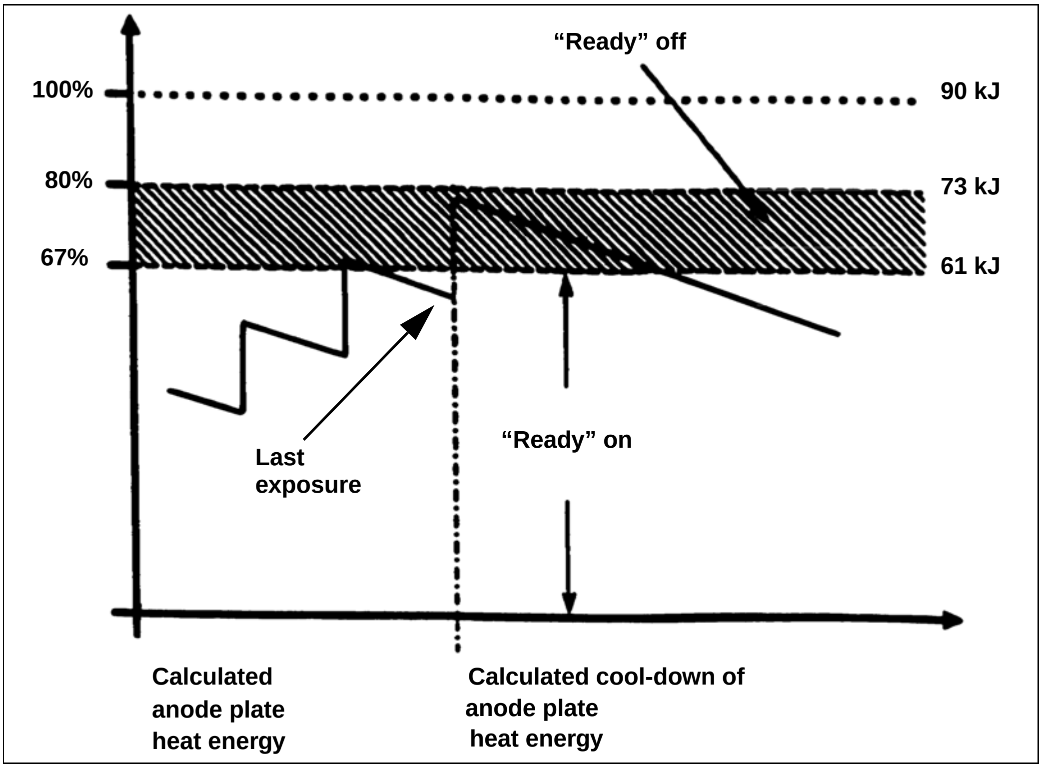


Fig. 1

The block diagrams and the wiring diagram SPR8-220.051..., sheet 140, are the basis of the functional description given below.

The tube load calculator consists of the CPU on board D1.

It fulfills two tasks:

1. it prevents the thermal loading of the anode disk from exceeding a maximum of 80% of the permissible load (in HU = Heat Units) and
2. it limits the long-term (one hour) mean value of the X-ray tube heat consumption to 75 W.

A so-called HU memory, in which the heat units are calculated and added from the kV and mAs values, is used with each exposure.

The content of the memory is constantly compared to a limit value of 80% thermal loading of HU.

Between exposures, the content of the HU memory is reduced by 13 Joules every 250 ms in order to simulate the cool-down characteristic of the X-ray tube assembly.
13 Joules represent about 52 W cooling capacity.

The actual cooling curve is somewhat steeper than the calculated one.

If, following the last exposure, the calculated anode plate heat energy is grater than 67% of the permissible thermal loading in HU, a new exposure is not allowed. Then the green "ready" LED on the control and display panel is turned on again, allowing a new exposure, only after the calculated anode plate heat energy has dropped again below the limiting value of 67%.

This ensures that the thermal loading never exceeds 80%.

A special algorithm in the microprocessor software ensures that:

1. the maximum anode plate heat energy can never exceeds 67% of the permissible thermal loading in HU + the maximum increase in thermal loading from an exposure and

2. the mean X-ray tube power can not exceed 73 W during one hour.

NOTICE	**To be able to calculate the cooling curve, the MOBILETT must be switched on.** **This means that if the MOBILETT has been used for a large numbers of exposures during the day, the operator must leave the device turned on for 10 to 20 minutes so that the HU memory can be emptied.**

If the unit´s monitoring system detects a fault during the execution of a function, a message will be shown in the parameter display on the control and display panel.

There are three types of error messages.

- messages with the designation “ERR”
- messages with the designation “CAL”, and
- messages with the designation “USE”.

Messages with the designation “ERR” indicate an erroneous parameter, e.g. when tolerance limits are exceeded.

Messages with the designation “CAL” indicate a fault in the execution of a function, or that important necessary conditions for the correct execution of individual functions in certain partial ranges no longer exist.

Messages with the designation “USE”, however, indicate the incorrectness of a parameter or of the execution of a function.

In any case, all three error types cause the:

- interruption of the routine just performed,
- several (19) beep tones generated by the buzzer on board D3 to signal this interruption,
- switch-off of the green “ready” LED on the control and display panel,
- if an error has occurred in the charging circuit for the capacitor bank, initiation of a capacitor discharge procedure.

The normal function of the buttons on the control and display panel is then disabled.

The error message can be acknowledged by pressing the selection button “kV+”. If several faults occur simultaneously, it may be necessary to press the selection buttons several times to return to normal function.

The capacitor bank is then charged again.

When the kV dependent final value of the capacitor potential is reached, the green “ready” LED on the control and display panel is also turned on again.

The unit is ready to operate.

Details concerning the meaning and elimination of error messages are given in the Service Instructions!

All of these messages are stored in a so-called “Error history memory” where they are available at any time for later analyses during servicing.

A maximum of 20 error messages can be stored in the error history memory.

The error history memory can be called up with the service program “P08” and cleared with program “P09”.

The selection procedure and details concerning the service programs mentioned are given in the Service Instructions.

This page intentionally left blank.

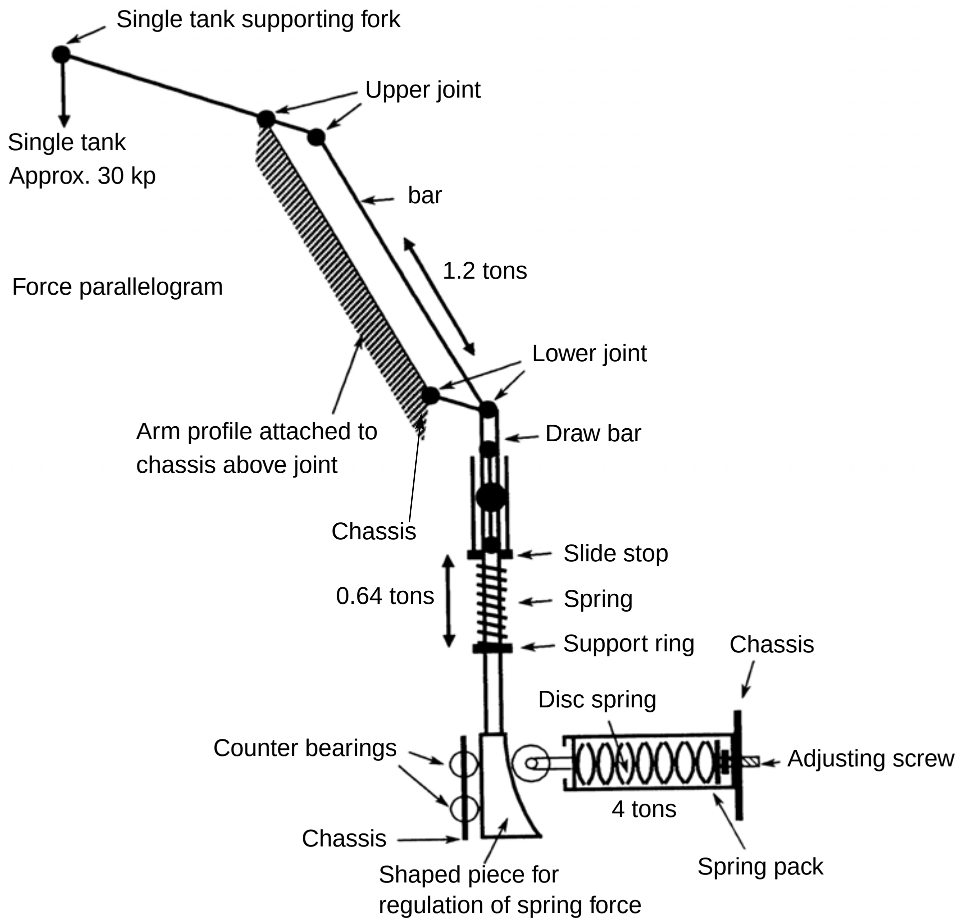


Fig. 1

The tensile forces acting in the articulated arm are balanced with a spring counterweight.

The weight of the single tank, its supporting fork and the upper arm, are transmitted by:

- the lever in the upper arm joint,
- the bar and
- the lever in the lower arm joint to the draw bar in the shaft of the arm (see Fig. 1).

The spring between the slide stop and the support ring compensates a constant tensile for the component.

The pressure on the roller of the shaped piece in the lower end of the arm shaft compensates those variable tensile force components arising due to different arm and single tank positions.

The tension of the disc springs in the spring pack can be varied with the adjusting screw.

⚠WARNING

Enormous tensile and compressive forces are acting in the articulated arm system.

Risk of personal injuries.

Follow the procedures exactly as described in the Maintenance Instruction or the Service instructions when performing repairs or adjustments.

This page intentionally left blank.

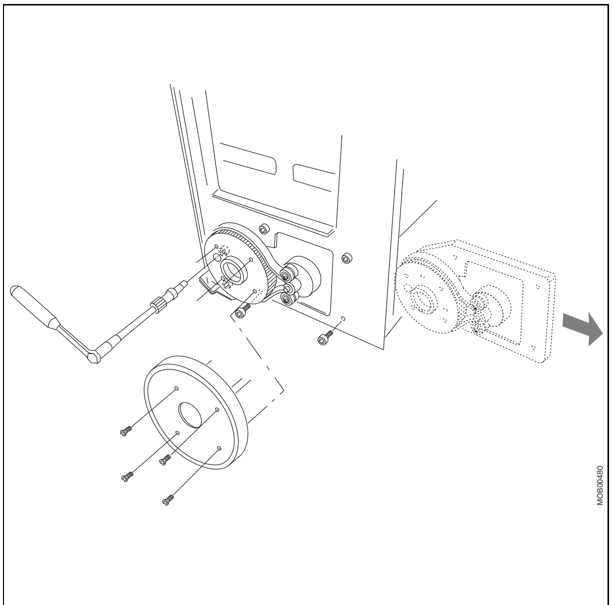


Fig. 1

The block diagrams and the wiring diagram SPR8-220.051..., sheet 190, are the basis of the functional description given below.

The motor power on MOBILETT Plus HP is enabled with the main switch S11 in position M. The operation is controlled by the user through the forward/reverse switch S101 and the high/low speed switches S102 and S103. For forward driving there are two speeds selectable. In reverse only one speed is selectable.

The power to the wheels is supplied by two 24 VDC motors. The motors and the power transmission to the wheels is designed as a separate unit M101 (Fig. 1).

The motor power system is supplied with 200 VDC from the battery circuit. The DC/DC converter (D110) converts the 200 VDC battery voltage to 24 VDC for the motor control.

The motor speed is controlled by the motor control board (D102a). The motor control board is a programmable permanent magnet speed controller. The speed is controlled by a four quadrant, full bridge power output which by pulse width modulation - at 15 kHz - provides the motors with forward speed, backward speed and braking. The acceleration up to full speed is linear for 3 s. The push-too-fast feature limits the maximum speed at which the MOBILETT can be pushed, thus protecting the MOBILETT, for example, from accelerating in steep inclines. A power save function turns off the motor control if it has not been used for 25 minutes. After that period the main switch has to be reactivated.

The signal connection board (D102c) connects the signals between user controls, DC/DC converter and motor control. The speed control potentiometer RP 1 is also located on the signal connection board.This potentiometer can be used to adjust the maximum speed individually. D101c also holds the fuse for the DC/DC converter input, U101 4AT.

NOTICE	**All faults on the motor power unit other than a blown fuse (V101 4AT) shall result in replacement of the whole motor power unit D102.**

This page intentionally left blank.

Chapter 1		Chapter "Protective measures for batteries B10 and capacitors in power conversion unit M10 and M11" revised.
	Page 2 - 1	Designation of batteries changed from A512/10.0 SR to A512/10 S.
Chapter 6		Changes in section "Recharging the whole set of 16 batteries"

This page intentionally left blank.